Claims

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. An internal combustion engine, comprising;

(a) a combustion cylinder including a cylinder and a reciprocating piston, said reciprocating piston oscillating within said cylinder in cycles which include a power stroke in which said piston moves from a top dead center position to a bottom dead center position and a return stroke in which said piston moves from said bottom dead center position to said top dead center position, said power stroke further divided into a first half portion and a second half portion and said return stroke further divided into a first half portion and a second half portion,

(b) a compressor for producing compressed air,

(c) a compressed air conduit communicating between the compressor and said combustion cylinder,

(d) a compressed air valve for opening and closing communication between said compressed air conduit and said combustion cylinder thereby intermittently allowing passage of a volume of compressed air into said combustion cylinder,

(e) a fuel injector for injecting fuel into said volume of compressed air,

(f) an exhaust means for releasing exhaust from said combustion cylinder,

(g) a timing system for

(i) opening said compressed air valve when said piston of said combustion cylinder is generally in said second half portion of said return stroke to transfer said volume of compressed air into said combustion cylinder,

(ii) activating said fuel injector after said compressed air valve has opened to inject fuel into said volume of compressed air to produce a combustible fuel - air mixture for subsequent combustion and expansion during said power stroke, and,

(iii) opening said exhaust means after said piston has entered said second portion of said power stroke to allow escape of exhaust gases.

2. The internal combustion engine of claim 1, further comprising,

a combustion initiator for initiating combustion of said fuel - air mixture, the activation of said combustion initiator timed by said timing system to occur after said fuel injector has been activated.

3. The internal combustion engine of claim 1, wherein,

said compressed air conduit further comprises a heat rejecting portion for cooling said at least a portion of said compressed air.

4. The internal combustion engine of claim 1, wherein,

said compressed air conduit further comprises a reservoir for accumulating and storing said compressed air.

5. The internal combustion engine of claim 1, wherein,

said compressed air conduit further comprises (i) a reservoir for accumulating and storing said compressed air and (ii) a heat rejecting portion for cooling said compressed air.

6. The internal combustion engine of claim 1, wherein,

said compressed air conduit further comprises (i) a reservoir for accumulating and storing said compressed air, (ii) a heat rejecting portion for cooling said compressed air, (iii) an outlet portion for conveying pressurized air to said combustion cylinder, (iv) a hot conduit for conveying uncooled compressed air to said outlet portion and (v) a cool conduit for conveying cooled pressurized air from the heat rejection portion to said outlet portion and at least one valve communicating between one of said hot conduit and said cool conduit for adjusting the proportion of cooled compressed air and uncooled compressed air for adjusting the temperature of the pressurized air in said outlet portion.

7. The internal combustion engine of claim 1, wherein,

said compressed air valve is operatively associated with said piston of said combustion of said combustion cylinder by said timing system to open communication between said compressed air conduit and said combustion cylinder during a portion of said cylinder cycle within said second half portion of said return stroke.

8. The internal combustion engine of claim 1, wherein,

said compressed air valve is a stem valve disposed in the head of said combustion cylinder and said stem valve is operatively associated with said piston of said combustion cylinder by said timing system to open communication between said compressed air conduit and said combustion cylinder during a portion of said cylinder cycle within said second half portion of said return stroke.

9. The internal combustion engine of claim 1, wherein,

said compressed air valve is a rotary valve that is operatively associated with said piston of said combustion cylinder by said timing system, said rotary valve including a passage for establishing intermittent communication between said compressed air conduit and said combustion cylinder during a portion of said cylinder cycle within said second half portion of said return stroke.

10. The internal combustion engine of claim 1, wherein,

said combustion cylinder further includes a connecting rod connecting said piston with a crankshaft for continuous rotation in response to said oscillating movement of said piston, and wherein, and,

said compressed air valve is an indexed rotary valve, said rotary valve including a valve body and an indexing means operatively coupling said valve body with said crankshaft for causing intermittent rotation of said valve body in response

to said continuous rotation of said crankshaft substantially when said piston is in said second half portion of said return stroke, said valve body including a passage for providing communication between said compressed air conduit and said combustion cylinder during a portion of said intermittent rotation of said valve body.

11. The internal combustion engine of claim 1, wherein,

said combustion cylinder further includes a connecting rod connecting said piston with a crankshaft for continuous rotation in response to said oscillating movement of said piston, and wherein, and,

said compressed air valve is an indexed rotary valve disposed between said compressed air conduit and said combustion cylinder, said indexed rotary valve further comprising a valve housing for enclosing a valve housing volume in pneumatic communication with said compressed air conduit, said valve housing having an injection port for communicating said valve housing volume with said combustion cylinder, a valve body rotatably disposed within said valve housing in sealed relationship with said injection port and including at least one passage for intermittently establishing pneumatic communication between said valve housing volume and said injection port, and an indexing means operatively associating said valve body and said crankshaft for intermittently rotating said valve body such that said at least one passage of said valve body establishes pneumatic communication

between said valve housing volume and said injection port to allow passage of said volume of compressed air into said combustion cylinder.

12. The internal combustion engine of claim 1, wherein,

said combustion cylinder further includes a connecting rod connecting said piston with a crankshaft for continuous rotation in response to said oscillating movement of said piston, and,

said compressed air valve is an indexed rotary valve disposed between said compressed air conduit and said combustion cylinder, said indexed rotary valve further comprising a valve housing for enclosing a valve housing volume in pneumatic communication with said compressed air conduit, said valve housing having an injection port communicating said valve housing volume with said combustion cylinder, a valve body rotatably disposed within said valve housing in sealed relationship with said injection port and including at least one passage for intermittently opening pneumatic communication between said valve housing volume and said injection port, and an indexing mechanism coupling between said valve body and said crankshaft for intermittently rotating said valve body such that said at least one passage of said valve body opens pneumatic communication between said valve housing and said injection port to convey said injection air into said combustion cylinder, said indexing mechanism including a drive wheel and an indexing wheel, said drive wheel coupled to said crankshaft for continuous rotation therewith, said drive wheel having at least one cog and a retaining disc, said

indexing wheel coupled to said valve body and having at least one slot for receiving said at least one cog of said drive wheel for intermittent motion of said indexing wheel in response to continuous rotating motion of said cog of said drive wheel during a first portion of the rotational cycle of said drive wheel, said indexing wheel further comprising at least one retaining feature compatible with said retaining disc of said drive wheel for retaining said indexing wheel in a stationary position during a second portion of the rotational cycle of said drive wheel, said valve body and said indexing wheel coupled such that pneumatic communication between said at least one passage of said valve body and said injection port occurs during said first portion of the rotational cycle of said drive wheel, said drive wheel and said crankshaft also coupled such that said first portion of the rotational cycle of said drive wheel occurs substantially when said piston is in said second half portion of said return stroke.

13. The internal combustion engine of claim 1, wherein,

said combustion cylinder is one of a plurality of combustion cylinders including connecting rods mechanically coupling the pistons of said combustion cylinders and a common crankshaft.

15. The internal combustion engine of claim 1, wherein,

said compressor includes a compression cylinder.

16. The internal combustion engine of claim 1, wherein,

said combustion cylinder includes a crankshaft and a connecting rod coupling the piston and the crankshaft, and

said compressor includes a compression cylinder including a piston mechanically coupled to said crankshaft.

17. The internal combustion engine of claim 1, wherein,

said combustion cylinder includes a first crankshaft and a connecting rod coupling the piston and a first crankshaft,

said compressor includes a compression cylinder includes a piston mechanically coupled to a second crankshaft,

said first crankshaft and said second crankshaft are operatively associated such that the relative speeds of rotation of said first crankshaft and said second crankshaft may be adjusted, whereby the adjustment of the relative speeds of rotation of said first crankshaft and said second crankshaft causes adjustment of air pressure within said compressed air conduit, such that the effective volumetric compression ratio of the engine may be adjusted.

18. The internal combustion engine of claim 1, wherein,

said combustion cylinder includes a first crankshaft and a connecting rod coupling the piston and a first crankshaft,

said compressor includes a compression cylinder includes a piston mechanically coupled to a second crankshaft,

said first crankshaft and said second crankshaft are operatively connected by a variable ratio gear box adapted for operation between a first ratio in which the ratio of speeds of rotation of said second crank to said first crank is relatively low and a second ratio in which the ratio of speeds of rotation of said second crank to said first crank is relatively high, said first ratio for maintaining air pressure in said compressed air conduit at a relatively low pressure corresponding to a relatively low volumetric compression ratio, said second ratio for maintaining air pressure in said compressed air conduit at a relatively high pressure corresponding to a relatively high compression ratio, said first ratio for relatively high efficiency and relatively low power density operation, said second ratio for relatively lower efficiency and relatively high power density operation.

19. In combination with an internal combustion engine of the type including a combustion chamber which oscillates between a minimum volume and a maximum volume during alternating expansion portions and contraction portions of successive cycles for causing continuous powered rotation of a drive shaft, a system for injecting compressed air into said combustion chamber comprising:

(a) a compressed air source in communication with said combustion chamber,

(b) an indexed rotary valve for governing communication between said compressed air source and said combustion chamber, said indexed rotary valve including a valve body and an indexing means operatively coupling said valve body with said drive shaft for causing intermittent rotation of said valve body in response to said continuous rotation of said drive shaft during portions of said successive cycles of said combustion chamber, said valve body including a passage for providing communication between said compressed air source and said combustion chamber during said intermittent rotation of said valve body.

20. The system of claim 19, wherein:

said compressed air source further comprises a compressor and a compressed air conduit communicating between said compressor and said combustion chamber.

21. The system of claim 19, wherein:

said compressed air source further comprises a compressor and a compressed air conduit communicating between said compressor and said combustion chamber and said compressed air conduit further comprises a heat rejecting portion for cooling said at least a portion of said compressed air.

22. The system of claim 19, wherein:

said compressed air source further comprises a reservoir for accumulating and storing said compressed air.

23. The system of claim 19, wherein:

said compressed air source further comprises (i) a reservoir for accumulating and storing said compressed air and (ii) a heat rejecting portion for cooling said compressed air.

24. The system of claim 19, wherein:

said compressed air source further comprises a compressor and a compressed air conduit communicating between said compressor and said combustion chamber and said compressed air conduit further comprises (i) a reservoir for accumulating and storing said compressed air, (ii) a heat rejecting portion for cooling said compressed air, (iii) an outlet portion for conveying pressurized air to said combustion cylinder, (iv) a hot conduit for conveying uncooled compressed air to said outlet portion and (v) a cool conduit for conveying cooled pressurized air from the heat rejection portion to said outlet portion and at least one valve communicating between one of said hot conduit and said cool conduit for adjusting the proportion of cooled compressed air and uncooled compressed air for adjusting the temperature of the pressurized air in said outlet portion.

25. The system of claim 19, wherein:

said indexing means comprises a drive wheel coupled to said drive shaft for continuous rotation therewith and an indexing wheel coupled to said valve body, said drive wheel and said indexing wheel having a first complementary set of engaging features for causing intermittent rotation of said indexing wheel in response to the continuous rotation of said drive wheel during a first portion of rotation of said drive wheel, said drive wheel and said indexing wheel having a second complementary set of engaging features for locking said indexing wheel from rotation during a second portion of rotation of said drive wheel, said indexing wheel coupled to said valve body such that said valve body passage provides communication between said compressed air source and said combustion chamber during said intermittent rotation of said indexing wheel and said valve body.

26. The system of claim 19, wherein:

said indexing means comprises a drive wheel coupled to said drive shaft for continuous rotation therewith and an indexing wheel coupled to said valve body, said drive wheel and said indexing wheel having a first complementary set of engaging features including at least one cog and at least one radial slot for receiving said cog for causing intermittent rotation of said indexing wheel in response to the continuous rotation of said drive wheel during a first portion of rotation of said drive wheel, said drive wheel and said indexing wheel having a second complementary set of engaging features including at least one scalloped portion in

said indexing wheel and at least one complementary circular retaining portion in said drive wheel for locking said indexing wheel from rotation during a second portion of rotation of said drive wheel, said indexing wheel coupled to said valve body such that said valve body passage provides communication between said compressed air source and said combustion chamber during said intermittent rotation of said indexing wheel and said valve body.